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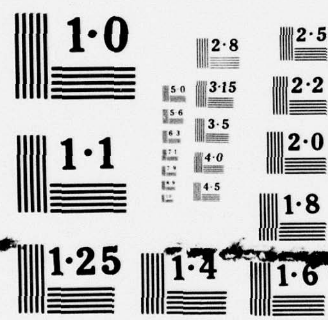
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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: The Evaluation of a Proposal for Incorporating an ECP on an OH-58A Light Observation Helicopter.

STUDY GOALS: To evaluate the effectiveness of the ECP on the original problem.

To evaluate the economics of incorporating the ECP.

STUDY REPORT ABSTRACT

The program manager (PM) in order to obtain the best information on which he can base his evaluation of an engineering change proposal (ECP), must of necessity call upon the services of functional elements outside of the program office.

This study report presents a detailed discussion of flight tests conducted by a functional element in order to provide the PM with a sound basis on which he can make a thorough assessment of the feasibility of accepting or rejecting the proposed ECP. Also included is a brief discussion of the economics of incorporating the ECP and some general conclusions on the overall effectiveness of the ECP on correcting the original problem.

KEY WORDS: MATERIEL DESIGN AND DEVELOPMENT AIRCRAFT HELICOPTERS ENGINEERING CHANGE PROPOSALS PROPOSAL EVALUATIONS PROGRAM MANAGEMENT

NAME, RANK, SERVICE	CLASS	DATE
Joseph C. Watts, GS-14 USA	74-1	15 May 1974

DEFENSE SYSTEMS MANAGEMENT SCHOOL

PROGRAM MANAGEMENT COURSE

INDIVIDUAL STUDY PROGRAM

THE EVALUATION OF A PROPOSAL FOR
INCORPORATING AN ECP ON AN
OH-58A LIGHT OBSERVATION HELICOPTER

STUDY REPORT
PMC 74-1

Joseph C. Watts
GS-14 DAC

FORT BELVOIR, VIRGINIA 22060

WATTS

THE EVALUATION OF A PROPOSAL FOR INCORPORATING AN ECP ON AN OH-58A LIGHT OBSERVATION HELICOPTER

An Executive Summary
of a
Study Report
by

Joseph C. Watts
GS-14 DAC

May 1974

Defense Systems Management School
Program Management Course
Class 74-1
Fort Belvoir, Virginia 22060

EXECUTIVE SUMMARY

The Gas Turbine Powered Light Observation Helicopter (LOH) emerged in the Army inventory in 1965. To fulfill the Army's requirement for increased capability, it was determined that an incremental purchase of LOH's was appropriate. The contract for the initial buy of 2,000 aircraft with option for a second buy of an additional 2,000 aircraft was awarded to Hughes Aircraft Company of Culver City, California. The Hughes Production Model LOH was designated as the OH-6A.

In 1968, prior to completion of delivery of the initial buy of 2,000 aircraft, the exigencies of the Service became such that the option to buy the additional 2,000 aircraft was necessary. Since Hughes was already behind in their delivery schedule of the initial buy, a contract was awarded to Bell Helicopter Company of Fort Worth, Texas. The contract was for a total of 2,200 aircraft, with the Bell Production Model being designated as the OH-58A. Accelerated delivery of the OH-58A was initiated in the fall of 1969.

After approximately eighteen months of operational use with the 1,250 aircraft that had been delivered, several instances of tail-boom buckling were experienced after an autorotational touchdown in the OH-58A Helicopter. Intensified research revealed that the tail-boom buckling resulted from a resonant condition between the main rotor and the natural frequencies of the fore and aft pylon mode and the tail-boom. Determination of the most logical means of correcting the problems was made and presented to the Program Manager (PM) as an Engineering Change Proposal (ECP).

To establish a sound basis on which to assess the proposed ECP, the PM called upon a functional element, the US Army Aviation Systems Test Activity at Edwards Air Force Base, California. A thorough flight test program was conducted to determine the effect incorporating the ECP on the OH-58A had on the original problem. In addition to assessing the effect incorporation of the ECP had on correcting the original problem, the effect on the overall performance of the OH-58A was also determined.

The results of the flight tests indicated that the proposed ECP was not effective in eliminating the original problem; however, by incorporating the ECP, the airspeed at which the tail-boom resonance occurred was increased beyond that which is normally used in accomplishing autorotational touchdown landings. Test results also indicated that the overall autorotational landing performance of the OH-58A Helicopter was degraded, especially at heavy gross weight and/or operations at density altitudes in excess of 5,000 feet. In view of the test results, incorporation of the proposed ECP was not considered economically feasible, and therefore, was disapproved.

THE EVALUATION OF A PROPOSAL FOR

INCORPORATING AN ECP ON AN

OH-58A LIGHT OBSERVATION HELICOPTER

STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 74-1

by

Joseph C. Watts
GS-14 DAC

May 1974

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CHAPTER 1

INTRODUCTION

Purpose

The purpose of this paper is to present one facet of the processing of ECPs in the PM office. Addressed herein is the role of operational test and evaluation that could be used in the ECP evaluation process.

Description

The OH-58A is a single-rotor, single-engine, light observation helicopter, manufactured by Bell Helicopter Company, Fort Worth, Texas. The aircraft is powered by an Allison T-63A-700 gas turbine engine. The engine is rated at 317 shaft horsepower for take-off, under sea-level standard day conditions, and 270 shaft horsepower for continuous operation.

The aircraft design incorporates a two-bladed, semi-rigid teetering main rotor and a two-bladed, anti-torque tail rotor. Designed for landing and take-off from prepared or unprepared surfaces, the aircraft is equipped with fixed, skid-type landing gear. The cockpit provides room for a pilot, on the right side of the aircraft, and a co-pilot/observer, on the left side of the aircraft. The cabin aft of the pilot and co-pilot provides room for cargo or seats for two passengers.

The design gross weight of the helicopter is 2,450 pounds, with a maximum take-off weight of 3,000 pounds. Fuel is provided in a single, self-sealing, bladder-type fuel cell located underneath the floor of the cabin area. The maximum capacity of the fuel cell is 73 gallons, which provides a maximum endurance of approximately three hours with no reserve.

Mission

The design mission of the OH-58A Helicopter is observation and reconnaissance. However, provisions for the installation of an M-27, 7.62 millimeter machine gun on the left side of the aircraft are incorporated.

CHAPTER 2

BACKGROUND

The Gas Turbine Powered Light Observation Helicopter (LOH) emerged in the Army inventory in 1965. To fulfill the Army's requirement for increased capability, it was determined that an incremental purchase of LOH's was appropriate. The contract for the initial buy of 2,000 aircraft with option for a second buy of an additional 2,000 aircraft was awarded to Hughes Aircraft Company of Culver City, California. The Hughes Production Model LOH was designated as the OH-6A.

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After approximately eighteen months of operational use with the 1,250 aircraft that had been delivered, several instances of tail-boom buckling were experienced after an autorotational touchdown in the OH-58A Helicopter.

These occurrences prompted the US Army Aviation Systems Command (AVSCOM) Light Observation Helicopter (LOH) Project Manager (PM) to enter into a Product Improvement Program (PIP) with the aircraft manufacturer, Bell Helicopter Company (BHC), to define the problem and recommend a

solution. This PIP task included computer studies, a shake test, and flight testing of a structurally instrumented OH-58A Helicopter. The results of the PIP task indicated that the tail-boom buckling resulted from a resonant condition between the main rotor and the natural frequencies of the fore and aft pylon mode and the tail-boom. The resonant frequency, 5 Hertz, was likely to occur at high blade angles (100 percent collective pitch) and low rotor speed (150 RPM), and was associated with large main rotor flapping excursions.

Three alternative solutions to this problem were considered: (1) change the natural frequencies of the fore and aft pylon mode and/or tail boom. This obviously would require extensive redesign and high cost; (2) dampen the pylon movement. This also would require some redesign and substantial cost; and (3) eliminate the excessive main rotor flapping. This could be accomplished with no redesign and at a reasonable cost. The BHC chose the third alternative by electing to restrict the maximum collective control travel which would, in turn, eliminate excessive blade flapping.

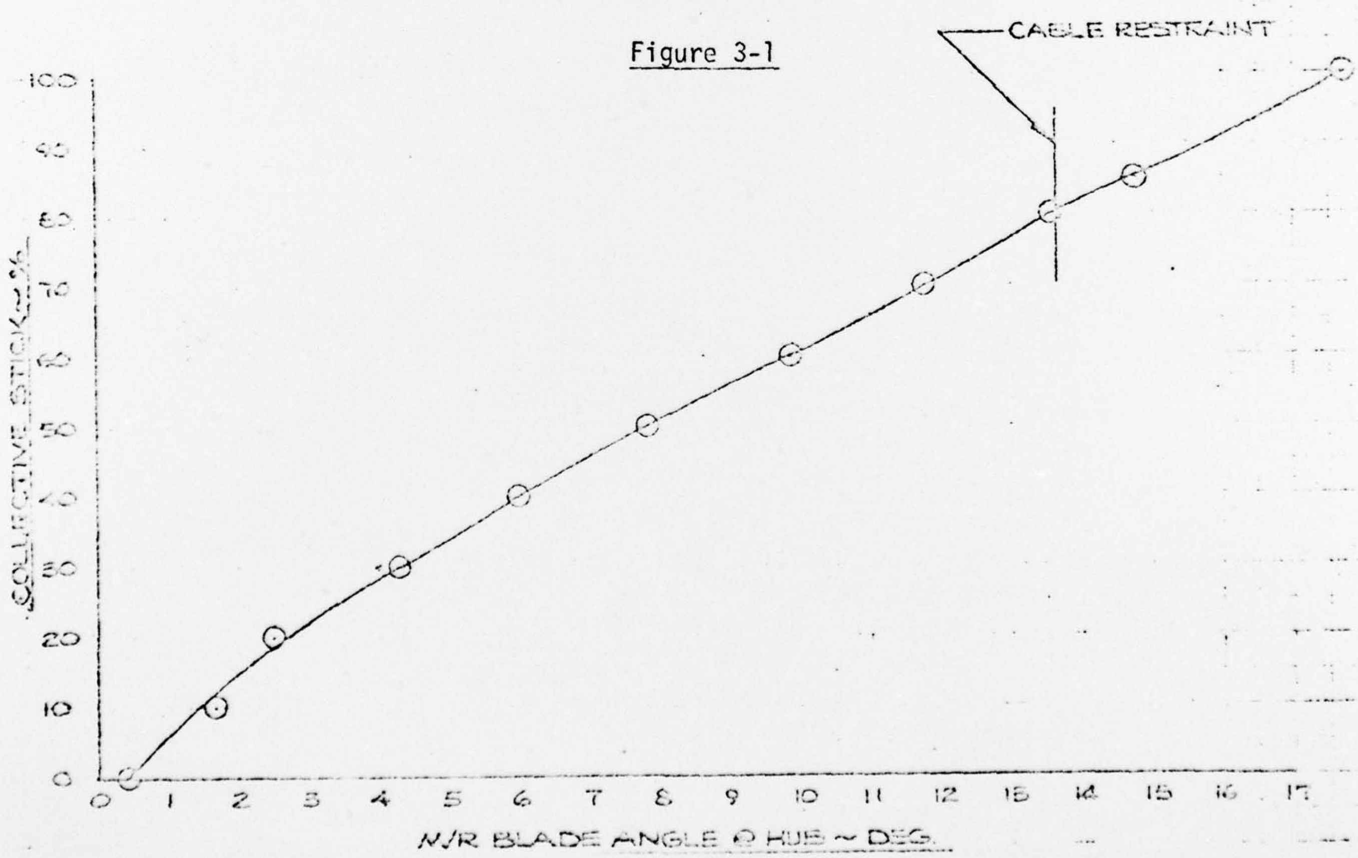
The seriousness of the problem warranted immediate attention, as an in-flight failure had been experienced after accomplishing an autorotative landing whereby tail-boom resonance was excited. The in-flight failure resulted in the fatality of the pilot trainee and the instructor, which caused immediate grounding of the entire fleet of OH-58A Helicopters.

CHAPTER 3

EVALUATING THE ENGINEERING CHANGE PROPOSAL

At the request of the PM, the manufacturer's approach to eliminating the tail-boom resonance problem was presented as an Engineering Change Proposal (ECP, OH-58A-140) for consideration. With the concurrence of the PM, BHC designed, fabricated, and installed the hardware proposed in the ECP on an OH-58A that had been bailed to the contractor. This hardware was a simple cable device installed in the control system such that the collective control travel was limited to 80 percent of the original total design travel. Figure 3-1 shows a plot or main rotor blade pitch angle versus collective control position.

Figure 3-1



Limited flight testing with the 80 percent collective pitch restriction device installed was conducted by BHC at their flight test facility in Arlington, Texas. These test results showed that there was no degradation of the helicopter performance and the excitation of tail-boom resonance was apparently eliminated.

Although the results of the manufacturer's limited flight tests indicated that incorporation of the proposed ECP was quite effective in eliminating the tail-boom resonance problem, the PM desired a more thorough investigation. To obtain the additional data desired, the PM requested the services of one of the functional elements in the Command, the US Army Aviation Systems Test Activity (USAASTA), at Edwards Air Force Base, California. The response of this organization was immediate and a flight test team, consisting of a test pilot and two flight test engineers, was dispatched to the manufacturer's facility at Arlington, Texas. After consulting with the manufacturer's flight test personnel, thoroughly inspecting the collective control restriction device installation and discussing their test results, the USAASTA test team decided upon a strategy to be used during their flight test effort. The nature of the problem, as understood from information given, was that the excitation of the tail-boom resonance was associated with high main rotor flapping, which resulted from high collective control settings and high relative wind inflow through the rotor disc. This being the case, the strategy chosen was to conduct autorotative landings at various airspeeds, using all of the available collective control prior to touchdown. After accomplishing several landings, using increased airspeed on each successive maneuver, without

encountering the excitation of tail-boom resonance, the decision was made to accomplish one additional autorotative landing at an absurd airspeed in excess of the airpseed normally used in the operational community. Using the same technique as previously used, the excitation of the tail-boom resonance was encountered during this final landing, resulting in minor skin damage to the tail-boom structure. This excitation of tail-boom resonance refuted the conclusions derived from the manufacturer's limited flight tests.

The PM was immediately apprised of the USAASTA flight test experience at the BHC facility. Prior to formulating any conclusions as to the relative merit of further consideration of incorporating the proposed ECP, the PM requested additional flight tests. The additional flight tests requested required assessment of the effect of incorporating the collective control restriction device on the OH-58A throughout the entire operational flight envelope of the helicopter. The scope of the additional testing included the determination of the performance degradation, if any, of the OH-58A's autorotational landing performance (height velocity) (HV) flight envelope resulting from the incorporation of the collective control restriction device. The overall test conditions are shown in Figure 3-2.

Figure 3-2

Test Site	Gross Weight (lb)	Density Altitude (ft)	Gross-Weight/ Density Ratio	Temperature (°C)
BHC[2]	2,990	-340	2,960	+7
	2,970	-700	2,910	+7
Bishop[3]	2,450	2,130	2,650	-4
	2,640	3,370	2,920	+2
	2,840	2,620	3,070	-5
Coyote Flats[3]	2,540	9,670	3,400	-2

[1]Wind speed: 4 to 7 knots.
[2]Center of gravity: FS 109.7.
[3]Center of gravity: FS 107.0.

Timing being of the essence, the additional flight testing had to be accomplished immediately in order for the PM to fully evaluate the ECP and take necessary action to restore the OH-58A fleet to flight status. To accomplish the additional flight tests requested by the PM, the collective control restriction device was installed on a later production model OH-58A organically assigned to USAASTA. In assessing the effect of incorporating the proposed ECP on the autorotative performance of the OH-58A throughout its entire operational envelope, tests were conducted at auxiliary test sites in the vicinity of Bishop, California. The tests were conducted at gross weights up to the maximum allowable (3,000 pounds) at a field elevation of 4,100 feet above sea

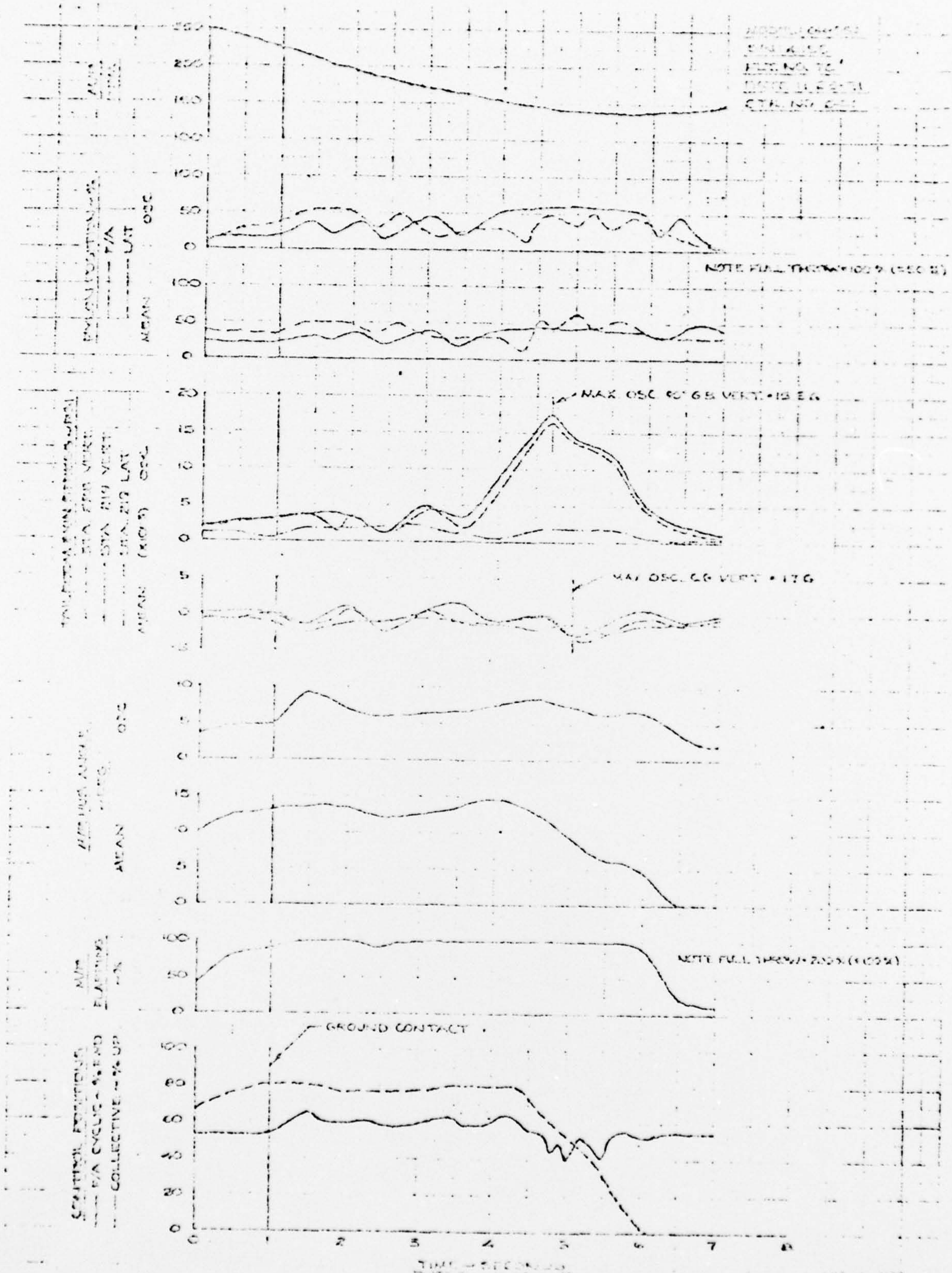
level and at gross weights up to the maximum allowable according to the weight-altitude limitations specified in the operator's manual at a field elevation of 9,500 feet above sea level.

In conducting the tests at the auxiliary test sites, the same test techniques and test criteria were utilized as were used during the limited flight tests conducted by the USAASTA test team at the manufacturer's flight test facility. After accomplishing several autorotative landings, at both auxiliary test sites, the excitation of tail-boom resonance was not encountered, even at touchdown speeds where tail-boom resonance had previously been encountered. At the 9,500 feet test site, however, a very noticeable degradation of autorotative landing performance was experienced. This degradation of performance can be directly attributed to the 80 percent limitation of collective control travel and the requirement for increased lift caused by a decrease in air density.

Presented in Figure 3-3 is a typical time history of an autorotative landing whereby tail-boom resonance was encountered. As may be seen in this figure, all of the available collective control was applied approximately .20 seconds prior to actual touchdown. As also may be noted in this figure, main rotor flapping reached 100 percent approximately .35 seconds after touchdown. As previously stated, the touchdown airspeed during this maneuver was approximately 40 knots indicated, which is well in excess of that used operationally. Shown in this figure, no pilot control inputs contributed to the excitation of tail-boom resonance.

As a result of the flight tests conducted by the USAASTA test team at the manufacturer's flight test facility, it was determined that the

Figure 3-3


NOTE FULL THROW = 100 % (±50 %)
MAX OSC 10' G.S. VERT = 18 E.G.
MAX OSC. G.S. VERT = 17 G
NOTE FULL THROW = 200 % (±100 %)
GROUND CONTACT
MEAN
OSC
CONTROL POSITIONS
F/A CYCLIC - % FWD
COLLECTIVE - % UP
TIME - SECONDS

incorporation of the collective control restriction device did not preclude the excitation of tail-boom resonance. Incorporating the collective control restriction device did, however, extend the airspeed at which the onset of tail-boom resonance occurs beyond the airspeed utilized for touchdown during normal operations. Results of tests conducted at the high altitude test site (9,500 feet) revealed that a degradation in autorotative performance of the OH-58A is experienced with incorporation of the collective control restriction device.

Upon receipt of the overall flight test results, the PM was able to make a determination of the effectiveness of the ECP and take positive action toward restoring the OH-58A fleet to flight status. Based on the flight test results, the proposed ECP was determined to be technically inadequate in eliminating tail-boom resonance and therefore was disapproved.

In this PM office, the normal routine for processing an ECP would first be an examination by the systems engineering group for technical adequacy. If it is found to be technically adequate, it is then passed on to the configuration control group for evaluation. The ECP is then passed on to the PM for final approval. The proposed ECP in question was found to be technically inadequate; therefore, it was not evaluated by the configuration control group prior to disapproval by the PM.

After disapproval of the proposed ECP, no further attempts were made to eliminate the tail-boom resonance problem. Instead, at the recommendation of the flight test agency, a change in the operational techniques in accomplishing autorotational landings in the OH-58A was adopted. Adoption of a new

operational technique which avoided the tail-boom resonance problem required a change in the operator's manual. The required change was accomplished at the routine manual change review.

CHAPTER 4

COST

At the time of the emergence of the tail-boom resonance problem, approximately 1,250 aircraft had already been delivered to the Army, with an additional 950 due off the production line. Included with submission of the proposed ECP was information concerning the cost of incorporation. The information on cost was presented as a package plan, with the overall cost quote of $62,416 for incorporating the ECP on the entire fleet of 2,200 aircraft. The following breakdown into unit cost was subsequently requested and obtained:

AIRCRAFT	UNIT COST		TOTAL
Production Line (950)	$29.00		$28,050
Delivered (1,250)	17.00		21,250
		TOTAL:	49,300
Total Package Cost			62,416
		DIFFERENCE:	$13,116

The difference between the sum of the two and the total package was for engineering design, tooling, and material.

Since the test results indicated that incorporating the ECP did not eliminate the excitation of tail-boom resonance, it was technically inadequate. Therefore, expenditure of funds in any amount to incorporate such an ECP was not considered prudent or economically justifiable.

CHAPTER 5

CONCLUSIONS

Based on the results of flight test data, it was concluded that incorporating the proposed ECP does not effectively preclude the excitation of tail-boom resonance in the OH-58A. In restricting the collective control travel to 80 percent of normal travel, the airspeed at which the onset of tail-boom resonance occurs was extended out beyond the airspeed normally used during termination in autorotative landings. Whereas the airspeed for onset of tail-boom resonance was improved, the overall autorotative landing performance of the OH-58A Helicopter was degraded, especially at heavy gross weight and/or operations at density altitudes in excess of 5,000 feet.

Since the incorporation of the proposed ECP did not eliminate the original tail-boom resonance problem, it was technically inadequate. Therefore, expenditure of funds to incorporate such an ECP was not considered prudent or economically justifiable.

EPILOG

At the time of research for material to produce this paper, the project manager's office had been disestablished. All records had been disposed of, with no corporate memory. Therefore, neither the personnel that comprised the configuration control group nor the details of the ECP process could be obtained.

This points out the need to modify the current system and establish some procedure whereby some corporate memory remains of the PM's office for a given period of time after the program has been deprojectized.

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1. Final Report, United States Army Aviation Systems Test Activity, Edwards AFB, California, 29 February 1972, subject: OH-58A Autorotational Evaluation, USAASTA, Project No. 71-46.

   This report contains flight test data that supports the discussion in this study report.

2. Technical Manual, TM 55-1520-228-10, Operators Manual, Army Model OH-58A Helicopter, 7 September 1972.

   This manual contains a detailed description of the aircraft with associated operating limitations.

3. Bell Helicopter Company, Fort Worth, Texas, Flight Test Division, Telecommunications.

   This was a telephone interview to obtain cost information from contractor project personnel.

4. Film Clip, *OH-58A Autorotations*, *September, 1972, 10 minutes.*

   Accession: US Army Aviation Systems Test Activity, Edwards AFB, California. This film clip dynamically demonstrates tail-boom resonance during flight test.